Solid Earth

ES-3 The student will demonstrate an understanding of the internal and external dynamics of solid Earth.

ES-3.2 Explain the differentiation of the structure of Earth's layers into a core, mantle, and crust based on the production of internal heat from the decay of isotopes and the role of gravitational energy.
Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/future knowledge: Students in 8th grade (8-3.1) understood the structure of the layers of Earth on the basis of position, density, and composition. Students have not been introduced to the reasons for this differentiation of internal structure.

It is essential for students to know that the layering of Earth into core, mantle and crust occurred early in Earth's formation because the temperature within the planet steadily increased due to decay of radioactive elements.

- Earth became so hot that at least some melting of original materials occurred and denser materials were pulled to the core.
- Heat from the core and radioactivity within the mantle keep the mantle hot.
- The gradual increase in temperature and pressure within Earth affects the physical properties and the mechanical behavior of Earth materials.
- Therefore, depending upon the temperature and pressure, a particular Earth material may behave like a solid, or like a puttylike material, or even melt and become a liquid in various Earth layers.

Core: The heavier material sank to become the core. At the extreme pressures found in the core, the iron-rich material becomes very dense. The solid inner core and the liquid outer core make up nearly one third of Earth's mass. The convective flow of metallic iron in the outer core generates Earth's magnetic field. Despite its high temperature, the material in the inner core under immense pressure behaves like a solid.

Mantle: The mantle is a zone of rock that makes up almost two-thirds of Earth's mass. It is divided into different regions – the top portion, along with the crust, is mostly igneous rock and is part of the *lithosphere*. The *asthenosphere*, below the lithosphere, is partially melted due to increases in pressure and temperature. In the lower mantle pressure increases and the rock material strengthens to a more rigid layer. Even so, the rocks are still hot and capable of very gradual flow.

Crust: Earth's outermost layer is the crust, a relatively cool, rigid shell. It makes up only about one percent of Earth's mass. There are two types of crustal material – oceanic crust and continental crust.

The behavior of seismic waves has allowed scientists to learn much about Earth's interior structure.

It is not essential for students to know the temperatures or distances for each of the layers.

Assessment Guidelines:
The objective of this indicator is to *explain* the structure of Earth 's layers; therefore, the primary focus of assessment should be to construct cause and effect models of how the production of internal heat and the role of gravitational energy effect the structure of Earth's crust, mantle, and core.
In addition to *explain* appropriate assessments may require students to:

- *compare* the layers of Earth;
- *sequence* the layers; or
- *identify* the layers or sub-layers based on properties.